

# OTT's Office of Advanced Automotive Technologies' Energy Management Team

Partnering with industry to develop  
promising battery concepts

U.S. DEPARTMENT  
OF ENERGY

OFFICE OF  
TRANSPORTATION  
TECHNOLOGIES



## Transportation FOR THE 21ST CENTURY

### Advanced Automotive Technology and the Battery Challenge

The U.S. Department of Energy (DOE) is working aggressively to promote advanced automotive technologies that will reduce dependence on the finite supply of oil, as well as alleviate the environmental impact of today's automobile. The DOE Energy Management Program is supporting development of energy storage technologies (secondary batteries) in collaboration with the United States Advanced Battery Consortium (USABC) and the Partnership for a New Generation of Vehicles (PNGV). The development focus is on high-energy batteries for electric vehicles (EVs) and high-power density batteries for hybrid electric vehicles (HEVs). DOE is working closely with its national laboratories, the auto industry and its suppliers, other government agencies, universities, and innovative small businesses to provide this vital research.

### How Does Government-Industry Collaboration Work?

The PNGV and USABC are true partnerships between government and industry. These partnerships have taken the lead in the development of several promising battery concepts including nickel-metal hydride, lithium-ion, and lithium polymer technologies. DOE sponsorship is helping private industry develop batteries to the point where industry can accept the risks of further development and commercialization. Each developer is conducting proprietary, multipart efforts to reduce the production cost and improve the performance and life of its specific technology. Battery systems must simultaneously meet extraordinary requirements such as high energy and power output, rechargeability, long life, abuse tolerance, and low cost.

### PNGV Supports High-Power Battery Development for Hybrid Vehicles

The Partnership for a New Generation of Vehicles (PNGV) is a cost-shared partnership between the Federal government and the U.S. Council for Automotive Research (USCAR), a consortium that includes DaimlerChrysler, Ford Motor Company, and General Motors Corporation. Launched as an historic initiative in 1993, PNGV pioneers a new method for government and industry to conduct business in support of national goals. The partnership's ultimate goal is the development of vehicles with a fuel efficiency of 80 mpg – three times that of today's six-passenger car, while maintaining such attributes as size, performance, safety, and cost. The first production prototypes are targeted for completion in 2004.

### USABC Supports High-Energy Battery Development for Electric Vehicles

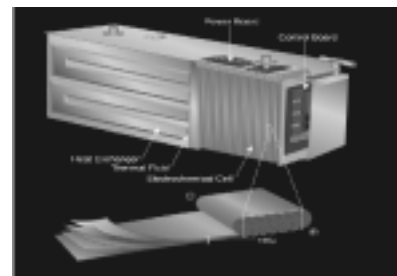
In 1991, the "Big Three" automakers, recognizing batteries as the key problem for electric vehicles, asked DOE to join with them in the USABC partnership to focus on developing an advanced battery industry in the United States. DOE national laboratories are supporting this program by performing critical research, development, testing, and evaluation of prototype battery systems. This cooperative effort has become the focus of DOE's Electric Vehicle Battery Program. The current USABC focus is on lithium-ion and lithium polymer batteries capable of meeting stringent goals for performance, life, sturdiness, and cost.



*Nickel-Metal Hydride  
Battery Module*



*High Power Lithium Ion 47V  
Battery Module*



*Lithium Polymer Battery  
Module Design*

## ADVANCED BATTERY GOALS FOR COMMERCIALIZATION

Electric Vehicle Battery Targets*		Hybrid Electric Vehicle Battery Targets**
Calendar Life	10 Years	10 Years
Cycle Life	1,000 cycles @ 80% DOD	200,000 cycles for 25 Wh pulses 50,000 cycles for 100 Wh pulses
Cost	<\$150/kWh (75 \$/kWh desired)	<\$150/kWh (75 \$/kWh desired)
Specific Energy	150 Wh/kg	75 Wh/kg
Energy Density	230 Wh/l	100 Wh/l
Specific Power	300 W/kg	750 W/kg
Power Density	460 W/l	1,000 W/l

\*EV Battery Targets based on USABC Interim Commercialization Criteria for High Energy Batteries.

\*\*HEV Battery Targets based on PNGV/USABC High Power Energy Storage Requirements - Fast Response Engine (Power Assist Hybrid)

### Glossary

**Calendar life:** The length of time a battery can undergo some defined operation before failing to meet its specified end-of-life criteria.

**Capacity:** Amount of electricity in the battery. Measured in Ampere hours (Ahr).

**Cycle life:** The number of times a battery can be charged and discharged before performance degrades.

**Current:** Rate of electron flow. Measured in amperes.

**Depth of Discharge (DOD):** 100% - State of Charge (SOC).

**Energy density:** The amount of energy a battery stores per unit volume at a specified discharge rate; also called volumetric energy density. Measured in watt-hours per liter (Wh/l).

**Power density:** The amount of power a battery can deliver per unit volume at a specified state-of-charge; also called volumetric power density. Measured in watts per liter (W/l).

**Specific energy:** The amount of energy a battery stores per unit mass at a specified discharge rate; also called gravimetric energy density. Measured in watt-hours per kilogram (Wh/g). This affects driving range.

**Specific power:** The amount of power a battery can deliver per unit mass at a specified state-of-charge; also called gravimetric power density. Measured in watts per kilogram (W/kg). This affects acceleration and hill climbing ability.

**State-of-Charge (SOC):** The percentage of its total ampere-hour capacity stored in a battery.

For more information on how DOE is helping America remain competitive in the 21<sup>st</sup> century, please contact:

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